ATTRACTING PARASITIC FLIES (DIPTERA: PHORIDAE) TO INJURED WORKERS OF THE GIANT ANT *DINOPONERA GIGANTEA* (HYMENOPTERA: FORMICIDAE)[1]

Arley J. Silveira-Costa[2,3], Paulo R.S. Moutinho[4]

ABSTRACT: Flies of the genus *Apocephalus* are common parasites of worker ants. Although the mechanisms used by parasitic flies to find their host are not well understood, olfactory cues have been suggested as the mechanism for host location, especially when the host ant is injured. In this study we describe, for the first time, parasitism of *Dinoponera gigantea,* a monomorphic neotropical ant species, by flies of the genus *Apocephalus* and test the hypothesis that injured worker ants attract more parasites than uninjured ones. We also evaluate the attractiveness of haemolynph produced by injury. To test the attractiveness of worker ants to *Apocephalus* flies, ants were divided into three groups. Group A was composed of injured workers, group B of workers with no injury, and group C of uninjured workers, but with a drop of the haemolynph from the injury of workers. Injured workers suffered more attacks by flies than uninjured ones, but there was no difference between uninjured workers with and without haemolynph on the body. Our data suggest that injury on the worker body of *Dinoponera gigantea* represents an important attracting stimulus for parasitic Phoridae, as demonstrated for other ponerine ants.

Parasitic flies (Diptera: Phoridae) attack a variety of species of ants (Borgmeier 1931, Brown and Feener 1991a, Feener 1981, Feener and Brown 1992, Feener and Moss 1990, Orr 1992, Pesquero *et al.* 1993). Female phorids use a sclerotized ovipositor to place their eggs in worker ants. The presence of these flies may cause dramatic reduction in the competitive ability and foraging activity of ant colonies and workers (Feener 1981, Feener 1988, Feener and Brown 1992, Feener and Moss 1990, Orr *et al.* 1995). These flies are recognized as potential biological control species for some pest ants, for example, the imported fire ant, *Solenopsis invicta* (Feener and Brown 1992, Orr *et al.* 1995). Very little is known, however, about how these phorids locate their hosts. Visual, olfactory or audio cues, or some combination of the three, may be used by phorids. In host ant species that present morphological castes (for example *Pheidole* spp., *Solenopsis* spp. and *Atta* spp.), phorid flies frequently attack large-sized workers (i.e. soldiers), indicating host selection through visual cues (Feener 1981, Feener 1987, Feener and Moss 1990). Nevertheless, the mechanism used

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[2] Pós-Graduação em Psicologia, DPE/Centro de Filosofia e Ciências Humanas, Universidade Federal do Pará, 66075-100 Belém, Pará, Brazil.

[3] Present address: Fundação Universidade Federal do Amapá, Rodovia Juscelino Kubitscheck de Oliveira, Km 02, 68902-280 Macapá, Amapa, Brazil.

[4] Instituto de Pesquisa Ambiental da Amazônia (IPAM) and DPE/Centro de Filosofia e Ciências Humanas, Universidade Federal do Pará, 66075-100 Belém, Pará, Brazil.

by phorids to find monomorphic ant species may be through olfactory cues. Brown and Feener (1991a) found that *Apocephalus paraponerae* was attracted by extracts of crushed ant workers of a giant and common neotropical ant *Paraponera clavata.* These results suggested that phorid flies use olfactory cues to find host ant species, and showed that phorids may select injured workers to place their eggs. We searched for evidence of parasitism by phorids on the neotropical giant ant *Dinoponera gigantea,* and tested the hypothesis that injured workers attract more phorid flies than uninjured ones. This study is the first record for parasitism by two phorid species, *Apocephalus miricauda* and *Apocephalus* sp. (probably a new species, B.V. Brown pers. com.) on *D. gigantea,* as well as the first host record for *Apocephalus miricauda.* We present evidence about the cues used by phorid flies to attack monomorphic ant species.

MATERIAL AND METHODS

Study Area

This work was carried out in a secondary forest area in Vitória Farm (2° 55' S, 47° 35' W), Paragominas, northeastern Pará State, Brazil (see Nepstad *et al.* 1991 for detailed description of the area), between 6 and 14 May, 1994. In this area, *Dinoponera gigantea* is a common ant species, easily found on the forest floor. Phorid flies are also easily found, especially during the day.

Attractiveness experiments

We tested the hypothesis that injured workers of *D. gigantea* attract more phorid flies than uninjured ones by subjecting 111 workers, divided in three experimental groups, to attacks of phorids. The experimental groups were: group A – injured workers; group B – uninjured; and group C – uninjured workers, on which a drop of haemolymph extracted from injured workers was placed upon the pronotum with the aid of a small brush. The injury on workers of group A was caused by a small incision between pronotum and mesonotum, using an entomological pin. All workers from different groups were handled in the same way as workers from group A, (including a simulation of perforation of pronotum, i.e. touching the worker body with the pin but with no perforation) to control for effects of alarm pheromone on the attraction of phorid flies. To quantify the number of attacks by phorids on workers from each experimental group, each worker was placed only once (no repetition) in a box (51x43x7 cm) covered on the borders with Fluon (a substance that prevents ants from escaping), immediately after its capture in the field. Each experiment lasted 10 minutes and was conducted between 7:00 h and 18:00 h, under field conditions. After each attack, phorids were collected with an aspirator to avoid recording attacks for the same fly.

The differences among mean number of phorid attacks on ant workers *D. gigantea* between groups were tested by nonparametric Kruskal-Wallis test, due to non-normality of the data and heteroscedasticity of the variances. Significant differences among means were analyzed by nonparametric Tukey-type multiple comparisons (Zar 1984). Differences between number of workers attacked by group was determined by Chi-Square Analysis.

RESULTS

Two phorid species of the genus *Apocephalus* attacked workers of *D. gigantea* —*A. miricauda* Borgmeier and another species possibly not described in the literature (Brown, B.V. pers. com.). Phorid attack frequency on worker ants differed between the three experimental groups ($X^2 = 17.8$, df = 1, $p < 0.001$) (Table 1). The attacks may be described as a pass over or swoop, followed by the fly landing on the worker's body. During phorid attacks, workers frequently put their forelegs or antennae over the part of the body where the parasitic fly was located, or moved through the arena at a higher speed than when foraging. Sometimes this escape behavior was sufficient to remove phorids from the ant body, as also reported for other ant species generally attacked by phorids (Feener and Moss 1990, Feener 1988). Most of the worker ants that were attacked suffered one to three attacks (maximum of 15 attacks on injured workers) during their time in the box, irrespective of the experimental group (Figure 1). Workers from group A (injured workers) were attacked in higher frequency in relation to group B (uninjured workers) ($q = 5.514$, $p < 0.001$ nonparametric multiple comparation) and group C (uninjured workers with haemolymph) ($q = 3.795$, $p < 0.05$). There was no difference, however, between group B and C ($q = 1.179$, $p > 0.05$, Table 1).

DISCUSSION

The occurrence of attacks by two *Apocephalus* species on injured workers of *Dinoponera gigantea,* supports the idea that attraction to injured workers is common among phorid species, especially to injured ponerines, although some injured ants of *Atta* and *Eciton* genera do not attract parasitic flies (Brown and Feener 1991a,b and references there in). Brown and Feener (1991a) found a phorid species of the same genus, *A. paraponerae,* can attack injured workers of another giant ant species — *Paraponera clavata.* Results from our experiments suggest the possibility that phorids use an olfactory cue for locating potential host ants, as indicated by their preference for injured workers. However, we can not isolate the influence of visual detection of workers by the flies, due to the absence in our experiments of extracts of crushed workers, as used by Brown and Feener (1991a). The absence of a significant difference in the num-

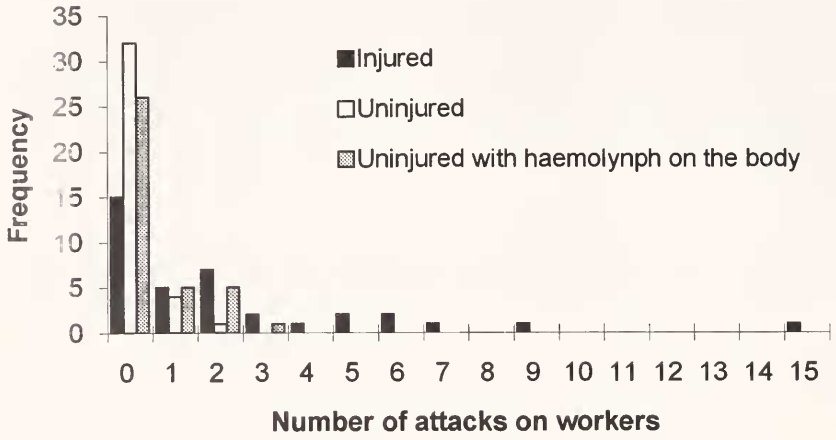

Figure 1. Frequency of attacks by Phoridae flies on workers of the giant ant *Dinoponera gigantea* from three experimental groups (see text).

Table 1. Number of attacks (mean ± SD) by Phoridae on ant workers (n = 111) of *Dinoponera gigantea* from three experimental groups (37 workers/group) (see text for details).

Experimental Group of ants	Number of workers attacked[§]	Number of attacks by phorids[‡] (mean ± SD)
Injured	22 [a]	82 (2.22 ± 3.17)[a]
Uninjured	5 [b]	6 (0.16 ± 0.44)[b]
Uninjured with injury-derived substance	11 [b]	18 (0.49 ± 0.84)[b]

The letters a and b indicate the statistical comparison between the means. Different letters indicate the presence of statistical difference ($p < 0.05$).

[§] Chi-Square Analysis ($X^2_{0.05,1} = 3.841$)

[‡] Nonparametric Tukey-type multiple comparation test ($q_{0.05,\infty,3} = 3.314$)

ber of attacks between groups B and C, however, indicates that the source of attraction is not in the substance extracted from the injury. During the process of injuring workers (group A), they released an extremely strong odor, not noted in groups B and C (despite the injuring simulation in workers of these two groups). It is therefore possible that a different substance from that extracted from the injury (*e.g.* an alarm or territorial pheromone) may attract phorids to injured workers (Ali and Morgan 1990). On the other hand, it is possible that the evaporation rate of the injury-derived substance on workers of group C was higher than the experiment duration, resulting in a low frequency of attacks by phorids.

Injured workers of *D. gigantea* as in *Paraponera clavata* (Brown and Feener 1991a) may be common in nature due to predation or intra-specific and inter-specific competition. Ants probably use an alarm pheromone during predation or competition by interference, so phorids could use the pheromone to find injured workers (Hölldobler and Wilson 1990).

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